

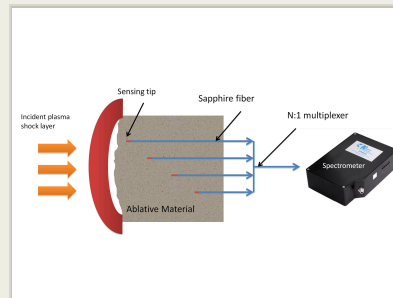
## Fiber-Optic Pyrometer for Thermal Protection Systems, Phase I

Completed Technology Project (2013 - 2013)



## Project Introduction

Surface temperatures in atmospheric reentry simulations range from 1500-2300 K, while stagnation temperature on the leading edge of a Mach 6 flight vehicle at 25 km altitude is 1817 K. Sensors that can operate at temperatures well above 1273 K are needed to provide reliable validation data for TPS modeling and design tools. We propose to develop a low-intrusive fiber-optical pyrometer capable of measuring temperature profiles within an ablating thermal protection system (TPS). In this concept a bundle of parallel sapphire fibers is embedded in a step-wise manner into a multilayered "plug" of TPS material. The sensing tip of each fiber consists of a metallic coating, forming an isothermal cavity; graybody emission from this cavity is transmitted through the fiber to a fiber-optic multiplexer, and thence to a compact near-infrared (NIR) spectrometer. By fitting the thermal spectrum from the shortest fiber to a Planck distribution (adjusted to account for spectral absorption in the sapphire fiber), a cold-side temperature can be inferred first. The next longest fiber can use this temperature to estimate the distorting effects of self-emission in the heated fiber. Sequential evaluation of fiber tip temperatures at known locations along the bundle will allow effective estimation of temperature gradient and subsequent calculation of heat flux. The proposed fiber-optic sensors are thermally and physically robust, lightweight, electrically passive, and immune to electromagnetic and radio-frequency interference. Additionally, our proposed fiber-optic pyrometer is optimized for high temperatures. As the TPS-embedded sensing tip temperature increases, the wavelength peak for the thermal emission spectrum moves from 2634 nm (at 1000 K) to 1260 nm (at the sapphire melting point of 2300 K), while the integrated spectral intensity increases as the 4th power of the temperature. Both effects improve the pyrometer signal-to-noise ratio.



Fiber-Optic Pyrometer for Thermal Protection Systems

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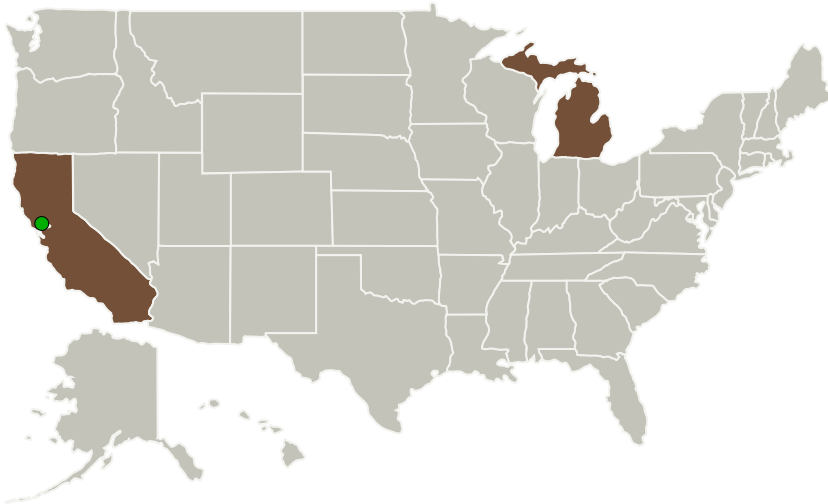
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## Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
ElectroDynamic Applications, Inc.	Lead Organization	Industry Minority-Owned Business	Ann Arbor, Michigan
● Ames Research Center(ARC)	Supporting Organization	NASA Center	Moffett Field, California

## Primary U.S. Work Locations

California	Michigan
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## Project Transitions

**May 2013:** Project Start**November 2013:** Closed out**Closeout Documentation:**

- Final Summary Chart(<https://techport.nasa.gov/file/138161>)

## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Organization:**

ElectroDynamic Applications, Inc.

**Responsible Program:**

Small Business Innovation Research/Small Business Tech Transfer

## Project Management

**Program Director:**

Jason L Kessler

**Program Manager:**

Carlos Torrez

**Principal Investigator:**

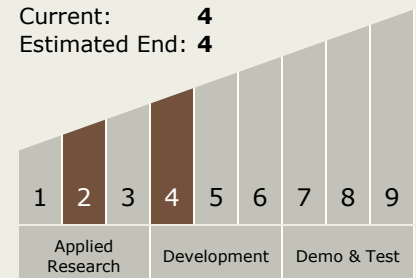
Christopher Davis

## Technology Maturity (TRL)

Start: 2

Current: 4

Estimated End: 4

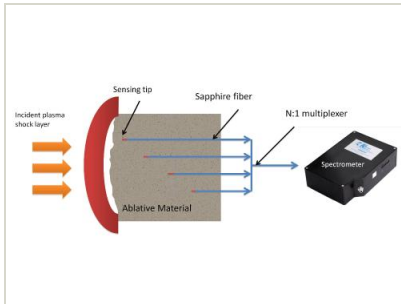


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## Images



### Project Image

Fiber-Optic Pyrometer for Thermal Protection Systems

(<https://techport.nasa.gov/image/135253>)

## Technology Areas

### Primary:

- TX09 Entry, Descent, and Landing
  - └ TX09.4 Vehicle Systems
    - └ TX09.4.6 Instrumentation and Health Monitoring for EDL

## Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System